THE NEXT GENERATION IN BIOFUELS - A NEW APPROACH TO THE PRODUCTION OF BIOFUELS

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Contents

Summary

As the world now awakens to the dire consequences of its continued reliance upon petroleum-based fuels, and in its mad rush to develop alternatives to such fuels, powerful consequences are being encountered in the development new biofuels to replace petroleum. With the development of the “first generation” biofuels, corn ethanol and biodiesel, powerful consequences are being encountered, from escalation in food prices throughout the world, to mass depletion of water supplies used in the production of such biofuels.

The next generation of biofuels now being sought after is “cellulosic ethanol” which is believe to be a solution to many of these problems caused by the first generation of corn ethanol biofuels. However, the realization of an economic pathway to “cellulosic ethanol” still eludes the scientific community and is said by many experts to still be five to ten years away from realization, a period of time which may ultimately be too late.

This Article explores an “interim generation” of biofuels which may have been overlooked, and that is a generation which hopefully learns from the mistakes of the first generation of biofuels and purports to solve many of the problems now faced by the current generation of biofuels, before it is too late!

What is this new, “interim generation” in biofuels development? Instead of constructing massive giant refineries which resemble the petroleum refineries which are costly to finance and are so dependent upon petroleum, alternatively, it is the “miniaturization” and downsizing of biofuels production plants which can solve many of the problems now being faced by these first generation of biofuels. Through the construction of smaller, distributed bio-fuels refineries which can draw upon many varied “free-sugar-based” feedstocks, these mini-refineries can be constructed globally and allow local communities to control their own energy destiny. Purpose grown crops such as sweet cane sorghum, food wastes and new corn hybrids can be grown throughout the U.S. and the world as feedstocks for these mini-refineries. In addition, these novel small-scale biorefineries can bring economic development to global regions as well as produce valuable food and nutraceutical products for a starving world. They will also protect valuable water supplies and produce environmental friendly materials to keep our planet clean.

Yet these mini-biorefineries are but a step in the right direction, a step which must be taken before time runs out. This Article will describe the benefits and advantages of taking this most important next step in the development of biofuels.

1. Introduction

The “first generation of biofuels” has been the development of ethanol and biodiesel and the “next generation” is usually considered to be “cellulosic ethanol”. The production of ethanol from corn and sugarcane are well-known processes dating back thousands of years based upon the simple process of sugar and starch fermentations [see also – *Technology and Economics of Fuel Ethanol from sugarcane*] The production of biodiesel [see also – *Biodiesel***]** dates back to 1940 to a process invented and patented by Colgate Palmolive which involves blending vegetable oils such as soy oil or rapeseed with an alcohol or acid converting them into biodiesel, a process known as transesterification. The substrates for these biofuels processes (starches, sugars and oils) are readily extracted from the grains used but the left-over ligno-cellulosic plant residues, such as corn stover, are not used in biofuels production today. Today, in the U.S. over 95% of ethanol is produced from corn.

The "second generation" of biofuels development, however, plans to convert these ligno-cellulosic crop residues or biomass into biofuels. This "generation" of biofuels is commonly referred to as "cellulosic ethanol", or a more accurate description might be "Biomass Ethanol" and this generation will rely upon the use of all sorts of biomass, including ligno-cellulosics from left-over plant residues (corn stover, rice/wheat straw, etc.) to other more challenging feedstocks such as wood, yard wastes, municipal solid and even food wastes such as citrus peel.

These "second generation" or "cellulosic ethanol" biofuels are focusing on two general technological approaches. The first approach will employ a biochemical approach utilizing enzymes to break the ligno-cellulose down into sugars and lignin. Some of these exotic enzymes include fungi known by G.I.'s who served in the jungles of the Pacific during WW II as "jungle rot". Other enzymes include those found in termite guts which digest wood into sugars.

A second technological approach relies upon the thermo-chemical gasification of ligno-cellulosics [see also – *Thermochemical conversions*] using high temperatures and pressures and catalytic methods to produce syngas, a gaseous stream composed of carbon monoxide and hydrogen which when pressurized at higher temperatures results in the production of synthetic biofuels.

Each of these "generation approaches" has major downfalls and technological challenges which must be overcome. Following are just a few of the problems associated with each of these "generation" approaches to biofuels production.

2. The First Generation of Biofuels

2.1 Corn and Sugarcane Ethanol and Biodiesel Processes

Nations are already experiencing the negative impact of diverting grains away from food production to fuel production. Service stations are now competing with super markets for the same grain. It is estimated that if the food value could be extracted from one tank full of ethanol, it would be enough to feed one person for one year. And, our world is seeing sharp escalations in the cost of almost every food product which relies on grain, from dairy, to poultry, to pork and beef, almost on a worldwide basis. Corn prices in the U.S. have doubled in one year from an average of $2 per bushel to $4 per bushel causing an increase in U.S. food prices by $14 billion per year. These prices could climb to $20 billion annually if oil prices go to $60-70 per barrel. If petroleum prices hit those levels, the demand for ethanol could increase to 30 billion annual gallons by 2012 and this would utilize over half of the U.S. annual corn crop. U.S. President Bush has set a goal of 35 billion gallons of annual production by 2012 which would result in a replacement of about 15% of total U.S. annual gasoline consumption.

Until the recent ethanol boom, over 60% of U.S. corn production went to animal feed. This has now been reduced by almost one-third.

2.2 The Ethanol Boom

It appears that corn farmers are really enjoying the demand for ethanol and the higher prices that corn is bringing. This "ethanol boom" is creating an almost "ethanol gold rush". But more and more farmers are becoming worried and ethanol is becoming more of a curse as farmers plant more corn than any time in the past 50 years. It would appear that ethanol would benefit the communities which grow the corn, but the problem is that the ethanol boom is really benefiting those at the top of the grain chain, the large agri-business giants that provide special genetically modified seeds at premiums, the fertilizers and pesticides, and the landlords. As usual farmers always finish last, and they don't keep the profits because their revenues go to paying their rising expenses. For example, within two months, fertilizer has doubled, and within the past four months, land values have increased by 40%. Though this seems like a great benefit to farmers, it really is not since most farmers rent their land and rental prices have risen by 20%. This makes it almost impossible for younger start-up farmers to get into business or to make an early go of farming once they are in business. Initially, coops benefit from the ethanol boom by constructing smaller ethanol plants, but now corporate investors from around the world are constructing ethanol plants that dwarf farmer owned plants. And, most of the incentives are going to these larger corporate owned plants. This is causing many farm co-ops to sell out to outside investors. According to the Coalition for Ethanol, of the 75 plants to be constructed within the next two years, only 25% will be farmer-owned. This will reduce farmers to mere work status. While corn prices may be at $4 per bushel, when these bushel prices decline, farmers could be left holding the bag by still having to pay the higher prices required to produce the bushel. In addition, the development of cellulosic ethanol could cause a crash in the demand for corn within the next few years, which could cause a farm crash and crisis and to lead to widespread foreclosures. And, it is predicted that the farm subsidies and fuel tax credits may not be renewed in the upcoming farm bill. So, the current ethanol boom shows just how vulnerable the current subsidy systems are.

2.3 Impact of Ethanol on Food Prices

Because of the increased use of corn for biofuels there has now been a $47 per capita increase in groceries in the U.S. since last July 2006, the study stated. This study goes on to predict that corn prices could peak at $4.42 per bushel and this would cause an increase in pork prices by 8.4%; poultry by 5%; beef by 4% with corn production increasing by 44% but exports decreasing by 63%. Some studies have stated that if this trend continued over the next decade, food prices could increase by 400—500%, and this could have a major impact on other corn importing nations. In the U.S. no more corn is available for ethanol production and growers are frantically switching every acre to corn production, including southern cotton farmers. Many U.S. growers are contemplating converting federal set aside acreage to corn production to meet the demand for corn ethanol markets.

And the impact of using grains for biofuels production on starving worlds is even more alarming as the U.S. currently produces 40% of all world corn production and supplies 70% of all corn to foreign countries. This is especially daunting in areas where over two billion of the world's poorer inhabitants spend more than half their annual income on such grains. Where will they get this grain now and what impact will this have upon starvation and on global peace and political stability (or instability)?

And, this "first generation of biofuels" is tied so closely to the use of petroleum and natural gas, all the way from the planting, to cultivating, harvesting, hauling, drying, and fertilizing with even insecticides and pesticides produced from petroleum. This results in over 30-40% of the production cost to produce one gallon of ethanol being attributed to the cost of the bushel of corn ($0.36/gallon). For every $1.00 in increased corn costs, the ethanol industry loses $15 billion dollars annually in profits. In 2005 less than 10% of the corn crop was used for ethanol production in the U.S. In 2007 almost 20%, and the USDA predicts 30% will be used within the next two years for ethanol production. Along with this increased demand for corn will be a 30% increase in farm land prices, according to the USDA. And now Congress is considering raising the demand for ethanol to 35% within the next ten years, which would require the use of 125% of all current corn crops in the U.S. And, thus, the cost of farmland will go up accordingly, and this will then have a major impact on building and construction costs as most new construction comes from farmlands.

2.4 Impact of Large Petroleum Refineries in the U.S. on Biofuels

And that is only the beginning of the strangleholds that oil has on this "first generation of biofuels". Petroleum and natural gas are used to grind, cook, steep, distill and dry the final product, and, it is used to ship the product across the country by truck, rail or barge, to isolated petroleum refineries which have diminished in number by almost 50% in the past 30 years—down from 315 in 1976 to only 149 in 2004 with no new ones constructed since 1981 when all subsidies were eliminated to construct new refineries [Jad Mouawad 2005]. Enough oil is available, at least for the time being, but there are simply not enough refineries. The U.S. currently uses 22 million barrels of oil per day but only has a refining capacity of 17 million barrels. In addition, environmental laws have made it very difficult, costly and time consuming to obtain permits to construct new ones. And, today, all smaller to medium size refineries have went out of business with most new refineries costing more than $1 billion each to construct. John D. Hofmeister, the president of Shell Oil Company in an interview with Times cited an investment firm report that said the biofuels push may "*rule out many refinery investments completely*." One consumer advocacy group says oil companies are spending more on stock buybacks and dividends than oil exploration or refining, with ExxonMobil, for example, spending $37.2 billion on buying back its stock and paying dividends to shareholders last year while putting only $3.3 billion toward exploration and refining. And profits for big oil have been record breaking. ExxonMobil led the pack with $39.5 billion in profits in 2006 and their first quarter profits this year were a tidy $9.3 billion. For comparison's sake, that was more than triple the profits of Microsoft last year. ConocoPhillips checked in at $15.6 billion last year, which was not too shabby either.

At these large-scale refineries, these "first generation biofuels" are then blended into the petroleum, with the refineries getting most or all of the blending subsidies or credits as incentives to use such biofuels in their formulas. Yet the value of these "first generation biofuels" is tied to the value of petroleum (gasoline and diesel fuel), as it goes up or down, so goes the profits of ethanol and biodiesel. Centralized refineries cause a great disparity in fuel prices across the U.S. where the farther away the fuel is shipped the higher the prices, e.g. on May 18, 2007 prices for gasoline in Oakland, California were \$3.61 per gallon versus \$2.91 in Baton Rouge, Louisiana where larger refineries are located.

2.5 The Impact of Petroleum on Food Production and Supplies

And, too there are no value-added products produced in these "first generation biofuels" plants, only ethanol and low-grade animal feed, or soy diesel and animal feed, and this has created an oversupply and major glut of animal feed on global world markets.

And there is the mounting concern that even our very food supplies are dependent upon the supply of petroleum to power the world's diesel truck markets to deliver our foods and goods, where it is estimated that every bite of food consumed in America travels an average 1300 "food miles" by truck to get to our supper table. In Canada this number exceeds 5000 "food miles". As the famous comedian George Carlin quipped in his address on *"On Losers": [paraphrased]: "If we run out of fuel, we run out of electricity, if we run out of electricity, we run out of heat and water, if we run out of water, we run out of food ,if we run out of food, we all die!"* The question is: Are we not running out of food and water due to our quest for biofuels development?

Consider the use of water in the production of our "first generation biofuels". There is no doubt that the current generation of biofuels is having an astounding and alarming demand on our nation's and world's water supplies. These "first generation biofuels" utilize enormous amounts of water. For example, it is estimated that approximately 2600 gallons of water is required to produce just one single gallon of ethanol, including water required to grow the corn stalk, and a 50 million gallon ethanol plant will utilize almost 200 million gallons of water per year just in the ethanol production cycle. If indeed 2600 total gallons are utilized, this means over 130 billion annual gallons are used to support just one single 50 million gallon ethanol plant. But the world has plenty of water? Think again. It is predicted in the U.S. alone that over one-half of the U.S. will be without water within 20 years! Predictions are confirmed that the West will see dust bowl drought conditions over the next decades similar to the dust bowl of the 1930's, but, it may not end. Even now the Ogallala Aquifer which underlies some ¼ of the area of the U.S. is down by almost 50% in the past 20 years. The largest water reservoirs in the U.S. which are on the Colorado River, Lake Mead and Lake Powell are now down by 50%.

So what has caused all of these problems with "the first generation of biofuels" development? How about simply "over engineering" and the premise that "bigger is always better". Now there are 200 and 300 million gallon ethanol and biodiesel plants in the planning stages which will cost \$300-\$500 million dollars each, and, companies such as BP and DuPont are now contemplating a bio-butanol plant in the U.K. that will cost $500 million. In essence, the biofuels plants of today are being modeled after the large-scale petroleum refineries, only the masters will change or become layered, because these huge biofuel plants are so closely tied to petroleum. And there is so much talk that we will all wake up one day to discover one of two things at the pump, 1) the price of gasoline has dipped to $0.50 per gallon, or 2) it has sky rocketed to $10.00 per gallon. If the former occurs, every ethanol plant in the U.S. will become a heap of scraps, or if the latter occurs, the ethanol industry will be controlled by just a few giants, or even by foreign investors.

3. The Second Generation of Biofuels: "Cellulosic Ethanol"

3.1 The Biomass Generation of Biofuels

This generation in biofuels development is usually divided into two main categories, the enzymatic treatment of biomass, or the gasification of biomass.

Energy Secretary Samuel Bodman has estimated that current gasification costs are about double that of the average $1.10 per gallon cost of a corn-based ethanol plants. Recently the U.S. DOE awarded approximately $300 million to just six companies to construct commercial demonstration models of these "second generation" biomass to biofuels processes. Two of these demonstration plants will utilize gasification, three will use fermentation technology and one will use a hybrid of gasification and fermentation. One of the companies will get $33 million to turn yard waste, wood waste and citrus peel into syngas, which would then be converted into ethanol, electricity and hydrogen. Another will get $76 million to convert timber scraps into syngas to make ethanol and methanol and another will get $76 million for an 11.4 million gallons-per-year plant that will use a combined biochemical and thermochemical process to convert corn stalks, wheat straw and switchgrass.

The problem with all of these is the very high capital costs associated with each "second generation" approach, and, it is estimated by the DOE that each process will require years, perhaps 5-10 more years before any of these processes can become commercially viable on their own merit without governmental funding.

3.2 What is the Real "Next Generation" of Biofuels?

So where does this put us in this world against big oil? The forecast certainly looks very bleak. Sometimes, however, the answers are right in front of us but we cannot see the forest for the trees. Sometimes we overcomplicate the answers and something very simple is overlooked. Perhaps the answer lies in not a single solution but a series of simple solutions strung together where one simple solution solves the next downstream problem, just as the success of the light bulb was not solely tied to the invention of the tungsten filament but was dependent upon many other discoveries, including electrical power generation in series and the discovery of alternating current. So we must start with one single premise, and build upon it. This author suggests that that premise should be tied to the "miniaturization" of biofuels production much like the premise of the miniaturization of computing which led to the development of the PC. And it is that word "miniature" which, in the eyes of this author, holds the true promise for the economic sustainability of biofuels production as will be explained hereinafter.

In today's "first generation biofuels" the buzzword is "bigger is better" and ostensibly this is believed to be necessary in order to achieve the economies of scale necessary to compete with the giant grain industries. Smaller farm coops and organizations are going up against the giant multi-faceted farm-based conglomerates such as the ADM's, Cargill's, and the pipeline giants such as the Williams' Bros. And so, the concern is competing with such giants at the larger-scale in order to achieve such economies. However, we must be careful as this could be an "engineering trap" in a world of over engineering, which has now led to a whole host of other problems. There are now a simple few who believe the true pathway to an economically sustainable renewable fuels industry is through smaller scale biorefinery plants based upon the premise that "smaller is beautiful" and more controllable, and, where a series of value added processes and technologies can be perfected in short order (within a year or so) which will overcome the massive problems now associated with the "first generation biofuels".

Therefore, perhaps a whole new generation in biofuels may have been overlooked, and, perhaps this new generation rests somewhere between the "first" and "second" generation of biofuels development. This "next generation" of biofuels capitalizes on the mistakes now faced by the "first generation of ethanol and biodiesel", and, the challenges faced in the development of the "second biomass or cellulosic generation" of biofuels. Perhaps this new generation of biofuels could be defined as the "Generation of Miniaturized Biofuel Refineries" or the "Mini-Biofuels Refinery" or "MBR's" for short [see also – *Biorefineries – concept for sustainability and human development*].

And so, what could this "generation of miniaturization" offer to the fledgling biofuels industry? Consider the following:

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Biographical Sketch

Sammy Mayfield Pierce

In 1980 Mr. Pierce founded EnerGenetics, one of the oldest alcohol fuels research companies in the U.S. In USDA sponsored publications EnerGenetics is considered to be one of the original pioneer companies in alcohol fuels research and development in the U.S. where he currently serves as EnerGenetics' Chairman and CEO.

Since 1980 Mr. Pierce has sponsored over $10 million on alcohol fuels research in conducted at 16 pilot plants which has involved over 100 PhD's at 12 major universities, the DOE's Oak Ridge National Laboratories, the USDA's Agricultural Research Service in Philadelphia and Ames, Iowa, and the Department of Navy at Woods Hole, Massachusetts. In addition EnerGenetics has received 3 grants from the USDA, 2 from the State of Iowa and one from the US Dept of Energy.

In 1980 Mr. Pierce and Professor Morris Wayman, Chairman of the Department of Chemical Engineering at the University of Toronto, co-invented the world's 1st bio-diesel fuel made from bio-butanol and the two researchers received a patent entitled: "Diesel Fuel by Fermentation of Wastes". In 1985 Mr. Pierce received the federal trademark for the name Bio-Diesel Fuel ™. Currently EnerGenetics holds and controls over 15 critical biofuels patents in collaboration with the USDA and four major universities.

Research Presentations, Papers and Affiliations.

EnerGenetics has been invited to participate as part of the famous ONAMI Engineering Center at Oregon State University located in Corvallis, Oregon where EnerGenetics will co-sponsor millions of dollars in biofuels research. EnerGenetics currently sponsors research at The Ohio State University, The USDA's Eastern Regional Research Center, The University of Hawaii, Oregon State University and Louisiana State University.

Since 1980, Mr. Pierce' work in biofuels has been featured coast to coast on the PBS television and radio networks where he was a monthly guest commentator on biofuels developments in the U.S. He also co-wrote and produced a documentary entitled "Biofuels, A Development in Its Infancy"—1986) which featured the famous Oscar nominated actor and World War II Silver Star veteran and hero, Mr. Eddie Albert, a dear friend and shareholder of Mr. Pierce's. Mr. Pierce's biofuels research has also been featured by the UPI and Associated Press networks, MSNBC, Forbes, the Wallstreet Journal's Dow Jones Market Research and in dozens of news papers coast to coast, including the Des Moines Register, the Chicago Tribune. His work has also been featured internationally in Mother Earth News Magazine, High Technology Magazine, Food Engineering and Food Process Design Magazines and other international trade journals.

Mr. Pierce has presented papers at international symposiums before the National Corn Growers' Association, the International Institute of Food Technologists, The National Association of Chemical and Biotechnology Engineers in San Francisco, the Engineering Class at the University of Louisiana and the International Biopolymers Research Institute.

Personal Information

Mr. Pierce's education and background is as a journalist where he has served as a local and national newspaper editor and syndicated columnist (in the Philippines). In high school he was a National Merit Science Scholar (top 1% of students nationwide). He also served as a US Army Reserve military intelligence officer. As a child he grew up as an orphan in the State of Mississippi, obtained the rank of Eagle Scout in Boy Scouting. In college he was the President of his student body. He has one son who now attends business school in Iowa.